SCREW ROTOR AND SCREW ROTOR COMPRESSOR

BACKGROUND OF THE INVENTION

The present invention relates to a rotor and a positive displacement compressor, and more particularly to a compressor which includes two rotors.

Positive displacement compressors including helical screw compressors as well as roots compressors are well known in the art. A helical compressor employs one male rotor axially aligned with and in combination with one female rotor. Usually the male rotor is the drive rotor driving the female rotor. In a compressor, one male rotor is commonly combined with one female rotor. Such a compressor is usually referred to as a twin helical screw rotor compressor.

An example of a known twin helical screw rotor compressor or screw compressor is shown in Figures 1 and 2 and is described briefly below.

A compressor 100 includes two mutually engaging screw rotors, of which a first rotor 101 is a male rotor and a second rotor 102 is a female rotor. The rotors 101, 102 are rotatably mounted in a working chamber that is delimited by a first end wall 103, a second end wall 104 and a barrel wall 105 that extends between the end walls 103, 104. As can be seen from Figure 2, the barrel wall 105 has a form that corresponds

generally to the form of two mutually intersecting cylinders. The compressor has an inlet port 108 at the first end wall 103 and an outlet port 109 at the second end wall 104.

The male rotor 101 has a rotor body 22 that includes a plurality of lobes 106 and intermediate grooves 111 which extend in a helical line along the rotor 22. Similarly, the female rotor 102 has a rotor body 23 that includes a plurality of lobes 107 and intermediate grooves 112 that extend in a helical line along the rotor 23. The major part of each lobe 107 on the male rotor 101 is located outwardly of the circle of contact with the female rotor 102, whereas the major part of each lobe 107 on the female rotor 102 is located inwardly of said circle of contact. The female rotor 102 will normally have more lobes than the male rotor 101. A typical combination is one in which the male rotor 101 has four lobes and the female rotor 102 six lobes, as shown in Figure 2.

The gas to be compressed, normally air, is delivered to the working space of the compressor through an inlet port 108 and is then compressed in V-shaped working chambers defined between the rotors and the chamber walls. Each chamber moves to the right in Figure 1, as the rotors 101, 102 rotate. The volume of a working chamber decreases continuously during the latter part of its cycle, after communication with the inlet port 108 has been cut off. The gas is therewith compressed and leaves the compressor

through an outlet port 109. The ratio of outlet pressure to inlet pressure is determined by the built-in volumetric relationship between the volume of a working chamber immediately after its communication with the inlet port 108 has been cut-off and its volume when it commences communication with the outlet port 109.

The male rotor 101 in Figure 1 has a shaft 21 around which the rotor body 22 is disposed. The male rotor body 22 has a first end surface 4 which lies in close proximity to the first end wall 103, and a second end surface 3 which lies in close proximity to the second end wall 104. The lobes 106 of the male rotor body 22 have crowns 5, shown linearly in Fig. 1. The female rotor 102 in Fig. 1 has a shaft 26 around which the rotor body 23 is disposed. The female rotor body 23 includes a first end surface 27 which lies in close proximity to the first end wall 103, and a second end surface 28 which lies in close proximity to the second end wall 104. The lobes 107 of the female rotor body 23 have crowns 15, shown linearly in Fig. 1.

Such a compressor is coupled to an electrical motor or combustion engine in order to rotate the male rotor 101 and is for example used to enhance the performance of an engine in a vehicle such as an automobile or to enhance the performance of a fuel cell due a higher inlet pressure of air or oxygen. As a consequence thereof, the engine or fuel cell can be produced

having a lower volume and mass. Also, there is a need for reducing the volume and weight of such a compressor for supercharging the engine or fuel cell.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a small compressor.

According to the present invention, a new rotor for a positive displacement compressor is provided which includes a non-rotating rotor shaft; a rotatable rotor body having end surfaces and surrounding the rotor shaft; and means for rotating the rotor body around the non-rotating rotor shaft.

In a preferred arrangement, the means for rotating the rotor body around the non-rotating rotor shaft comprises rotor magnets on the rotor body, wherein the magnets are arranged in a circle centered on an axis of the rotor body and facing the shaft; and an electrical stator provided on the shaft in registration with the rotor magnets. When the stator is electrically energized, the rotor body is caused to rotate about the non-rotating rotor shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a longitudinal sectional view of a Prior Art helical rotary screw compressor;

Figure 2 is a sectional view taken on line II-II in Figure 1;

Figure 3 is an end view showing two cooperating rotors of the present invention;

Figure 4 is a sectional view of the rotors shown in Figure 3 taken along line IV-IV;

Figure 5 is a sectional view corresponding to the view in Figure 4 including a compressor housing; and

Figure 6 is a sectional view of a radial induction bearing.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In Figures 3 and 4 two cooperating rotors for a screw rotor compressor according to the invention are illustrated. The left rotor 1 is a male rotor and the right rotor 21 is a female rotor.

The male rotor 1 comprises a rotor body 3 having the shape of a cylindrical shell. The outer surface of the rotor body 3 has helically extending lobes 6 separated by intermediate grooves 7. As is apparent from Figure 3, the male rotor body 3 has six lobes 6 and the same number of intermediate grooves 7. The inner surface 10 of the cylindrical shell of the male rotor body 3 is cylindrical. Further, the male rotor body 3 has parallel planar end surfaces 4 and 5. Inside of the male rotor body 3 a male rotor shaft 2 is arranged. The two end parts 2A

and 2B of the shaft 2 extend beyond the end surfaces 4, 5, respectively, of the male rotor body 3.

Two bearings 8, 9 are disposed in a spaced relationship between the shaft 2 and the inner surface 10 of the male rotor body 3. Between the bearings 8, 9 on the inner surface 10 of the male rotor body 3, permanent magnets 11 in the form of rods or bars are placed in parallel such that they form a cylindrical shell ring. The magnets 11 are secured to the rotor body 3. The magnets 11 may be arranged in an insert to be placed inside the rotor body 3 and fixed (i.e., bonded) to the inner surface 10 of the rotor body 3 or may be bonded separately to this surface 10 as is known in the art.

The male rotor shaft 2 is provided with an axially extending blind bore 13 opening in one of the planar ends thereof. Further, a bore 13A in the cylindrical surface of the shaft 2 is connected to (in communication with) the axial bore 13.

Electrical windings 12 are wound on the shaft 2 of the rotor 1 between the bearings 8, 9 in registration with the cylindrical shell of magnets 11. These windings 12 function as stator leads. End parts 14 of the windings 12 are passed through the bore 13A from the cylindrical surface of the shaft 2 and through the axial bore 13 to the outside of the shaft 2 and are connected to an electrical power source 80. The stator leads 13 when energized will cooperate with the ring shaped shell of

permanent magnets 11 in the same way as in an electrical motor. In this case, contrary to a conventional electrical motor, the outer part will rotate while the central part acts as a stator.

Similarly, as also shown in Figure 4, the right rotor 21 is a female screw rotor. The female rotor 21 comprises a female rotor body 23 having the shape of a cylindrical shell. The outer surface of the female rotor body 23 has helically extending lobes 26 separated by intermediate grooves 27. As is apparent from Figure 3, the female rotor body 23 has eight lobes 26 and the same number of intermediate grooves 27. The inner surface 30 of the cylindrical shell of the female rotor body 23 is cylindrical. Further, the female rotor body 23 has parallel planar end surfaces 24 and 25. Inside of the female rotor body 23 a female rotor shaft 22 is arranged. The two end parts 22A and 22B of the female rotor shaft 22 extend beyond the end surfaces 24, 25, respectively, of the female rotor body 23.

Two bearings 28, 29 are disposed in a spaced relationship between the female rotor shaft 22 and the inner surface 30 of the female rotor body 23. Between the bearings 28, 29 on the inner surface 30 of the female rotor body 23 permanent magnets 31 in the form of rods or bars are placed in parallel such that they form a cylindrical shell ring. The magnets 31 are secured to the female rotor body 23. The magnets 31 may be arranged in an insert to be placed inside the female rotor body 23 and be fixed

(i.e., bonded) to the inner surface 30 of the female rotor body 23 or may be bonded separately to this surface 30 as is known in the art.

The female rotor shaft 22 is provided with an axially extending blind bore 33 opening in one of the planar ends thereof. Further, a bore 33A in the cylindrical surface of the shaft 22 connects to (communicates with) the axial bore 33.

Electrical windings 32 are wound on the shaft 22 of the female rotor 21 between the bearings 28, 29 in registration with the cylindrical shell of magnets 31. The windings 32 function as stator leads. End parts 34 of the windings 32 are passed through the bore 33A from the cylindrical surface of the female rotor shaft 22 and through the axial bore 33 to the outside of the female rotor shaft 22 and are connected to an electrical power source 80. The stator leads 33 when energized will cooperate with the ring shaped shell of permanent magnets 31 in the same way as in an electrical motor. In this case, contrary to a conventional electrical motor, the outer part will rotate while the central part acts as a stator.

Figure 5 shows a sectional view of a compressor which includes the two rotors 1 and 21 of Figure 4. The compressor housing 40 comprises two parallel end walls 41 and 42 and a barrel wall 43 between the end walls 41, 42. The inside of the barrel wall 43 has the shape of two intersecting cylinders

corresponding to the diameters of the two rotors 1 and 21. The end parts of the rotor shaft 2, 22 are protruding into the end walls 41, 42 of the compressor housing 40. The configuration of the compressor housing corresponds to that shown in Figures 1 and 2 having an inlet port 44 and an outlet port 45.

Figure 6 is an enlarged sectional view (not to scale) of a part of a rotor shaft, and shows a radial induction bearing 60 between a shaft 61 and a rotor body 70 shown as a cylindrical shell. The shaft 61 is part of the bearing by serving as an inner stator-mounting rod. Two ring shaped axial magnets 62, 63 are fixed around the mounting rod 61 in a spaced relationship. The magnets 62, 63 have opposing magnetic directions (polarities). In the space between the magnets a spacer ring 64 is arranged with an iron washer 65 provided around the outside of the spacer ring 64. Also, second and third spacer rings 66, 67 bearing against the magnets 62, 63, respectively, are provided. Similarly, outside the spacer rings 66, 67 end plates 68, 69, respectively, are arranged. Such radial induction bearings are known in the art.

Reverting to Figure 5, the operation of the compressor will now be described. In order to start the rotation of the compressor rotors, the windings 12, 32 have to be energized. Upon energizing the windings, the rotor bodies 3, 23 will start to rotate. In this case both rotors are energized and separately

driven by electrical power. Since the male rotor 1 has 6 lobes and the female rotor 21 has 8 lobes, the rotational speeds of these rotors must differ. If the male rotor 1 has a rotational speed of N rpm the rotational speed of the female rotor 21 is 0.75N rpm. Generally, if the compressor male rotor has X lobes and the compressor female rotor has Y lobes, the rotational speed of the female rotor is (X/Y)*N rpm, where N is the rotational speed of the male rotor.

As seen from the foregoing, according to the present invention, a rotor for a positive displacement compressor comprises a non-rotating shaft around which a rotatable rotor body is mounted. The rotatable rotor body has a central bore in which the shaft is inserted. The rotor body has a shape which essentially corresponds to an elongated shell having planar parallel end walls. An outer surface of the rotor body comprises lobes and intermediate grooves helically extending between the end walls. There are typically at least 2 but less than 10 lobes and intermediate grooves. The lobes and grooves extend helically from the outer surface of the rotor body. The helical twist is preferably in a range of 5 - 90° for a roots compressor and 150 - 330° for a helical screw compressor. End parts of the rotor shaft extend beyond the rotor body and serve as trunnions. Two bearings are arranged in a space between the rotor shaft and

the rotor body in a spaced relationship. The bearings allow the rotor body to be rotated relative to the shaft.

Further, on an inner part of the rotor body facing the shaft, magnets are arranged in a circle around the shaft. Metal wires are wound on the shaft as electrical windings which are arranged such that, when fed with electrical power, the windings cooperate with the magnets in the rotor body. This cooperation results in rotation of the rotor body around the rotor shaft.

The positive displacement compressor according to the invention thus comprises a housing including a first and a second end wall, a barrel wall having an inner shape substantially corresponding to two intersecting cylinders between the end walls, an inlet port and an outlet port for fluid. Two cooperating rotors are mounted in parallel in the two intersecting cylinders. One of the rotors is a male rotor and the other one is a female rotor. The two end portions of the non-rotating shafts of the respective rotors are mounted in the end walls of the rotor housing.

Each of the rotors comprises a rotor body which has a central bore and is arranged rotatably around the non-rotating shaft, and bearings mounted on the shaft. The bearings are arranged in a spaced relationship near each end of the respective rotor body. Each rotor body is provided with magnets, preferably permanent magnets, arranged in a circle and facing the shaft. On

the periphery of the shaft there are windings for cooperation with the magnets on the rotor body. Both the windings and the magnets are arranged between the bearings. The windings have leads which are connectable to a power source. When the windings are energized, the respective rotors are caused to rotate, like a motor.

Each rotor body is provided with lobes and intermediate grooves on the outer surface. The lobes and grooves are preferably arranged as a helix. The male rotor body has usually two or more lobes. The number of lobes of the female rotor body is usually but not necessarily greater than the number of lobes of the male rotor body. Such a difference in the number of lobes requires that the two rotors rotate with different revolution units of time.

Additional advantages and modifications will occur to those readily skilled in the art. For example, although according to the present invention each of the rotors 1, 21 is driven by its own source of energy, in known compressors a motor drives one rotor while the other rotor is driven indirectly by the driven rotor or by means of synchronizing gears. Additionally, the bearings in the present compressor may be conventional bearings, such as roller bearings, or radial induction bearings. Preferably, at least one of the bearings 8, 9 and 28, 29, respectively, is a radial induction bearing. Various additional modifications may be made without departing from the spirit or

scope of the general inventive concept as defined by the appended claims and their equivalents.